

## An Analysis of Super Typhoon Tip (October 1979)

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### ABSTRACT

Super Typhoon Tip was an eventful tropical cyclone which developed in the western North Pacific in early October 1979. Besides establishing the world's record for the lowest minimum sea level pressure ever measured in a tropical cyclone, Tip also possessed the largest surface circulation pattern ever observed for a tropical cyclone. The development cycle of Super Typhoon Tip from a weak disturbance to a mature typhoon to an extratropical system is discussed in view of the record breaking performance of this typhoon.

### 1. Introduction

Super Typhoon<sup>3</sup> Tip was the most significant typhoon of the 1979 season, and possibly the most significant tropical cyclone of this century. Forty aircraft reconnaissance missions were flown on Tip by the 54th Weather Reconnaissance Squadron stationed at Andersen Air Force Base, Guam. These missions produced 60 storm fixes,<sup>4</sup> which made Super Typhoon Tip one of the most closely watched tropical cyclones in recent memory. Aircraft and synoptic data showed that Tip achieved the lowest sea level pressure ever observed in a tropical cyclone (870 mb) and also had the largest circulation pattern on record (nearly 2220 km in diameter).<sup>5</sup> This note describes the evolution of Super Typhoon Tip and is a product of the extensive post-analysis that the staff of the Joint Typhoon Warning Center (JTWC) performs for each tropical cyclone in the western North Pacific and North Indian Oceans. The results of these post-analyses are published by JTWC in the Annual Typhoon Reports.

### 2. Development stage

Satellite and synoptic data during the early part of October revealed an active monsoon trough that extended from the Marshall Islands through the Caroline Islands to Luzon. Three significant circulations developed in this trough: one near Manila, which would become Typhoon Sarah; another southwest of Guam, which would become Tropical Storm Roger; and the last between Truk and Ponape, which was destined to become Super Typhoon Tip.

It is not possible to discuss the development of Tip without, at the same time, examining the development of Tropical Storm Roger. The surface analysis for 0000 GMT 3 October 1979 revealed three circulations in the monsoon trough with strong cross-equatorial flow between Guam and the Philippine Islands, most of which was feeding into Tropical Storm Roger (Fig. 1). This surface flow pattern was enhanced, in part, by an extra-tropical trough north of Roger over southern Japan. The split in the surface flow pattern near Guam tended to keep Tip from developing while southeast of Guam. The upper level (200 mb) analysis at the same time showed a large anticyclone north of Guam and a developing tropical upper tropospheric trough (TUTT) cell ~550 km east of Marcus Island (Fig. 2). The TUTT cell was moving slowly westward. Strong upper level northeasterlies between Truk and Ponape prevented the development of an upper level outflow channel to the northeast.

The satellite signature of the tropical disturbance near Truk continued to show improvement despite the initially unfavorable upper air pattern. A recon-

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<sup>3</sup> A typhoon is designated a "super typhoon" when maximum surface winds reach a velocity of  $67 \text{ m s}^{-1}$ .

<sup>4</sup> A fix is defined as the position of the surface or 700 mb circulation center as determined by actual reconnaissance aircraft penetration of the tropical cyclone.

<sup>5</sup> The size of the circulation pattern is determined by the diameter of the highest closed isobar associated with the tropical cyclone.



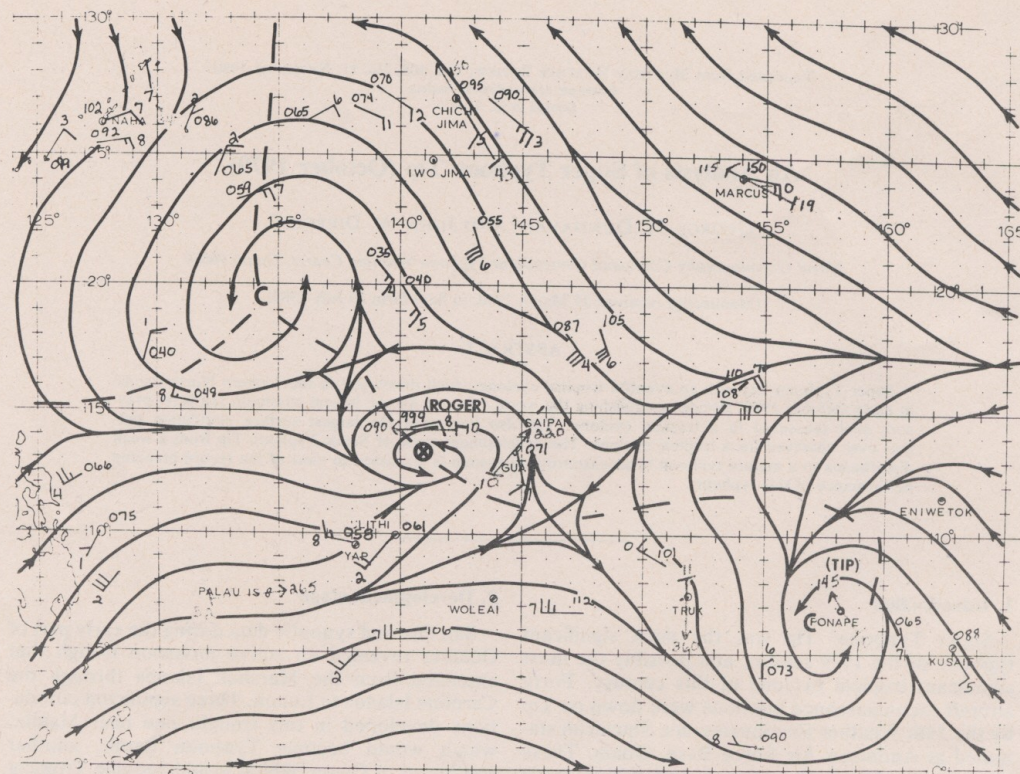


FIG. 1. The 0000 GMT 3 October 1979 surface streamline analysis. Surface (—) and gradient-level (---) wind data are in knots and surface pressures are in millibars.

naissance aircraft at 0800 GMT 4 October 1979 found a closed surface circulation ~220 km southeast of Truk with a minimum sea level pressure of 1003.9 mb and a maximum estimated surface wind<sup>6</sup> of  $13 \text{ m s}^{-1}$ .

A reconnaissance aircraft fixed the disturbance the following day at ~185 km southeast of the previous position. Based on indications of continual development, the first tropical cyclone warning on Tropical Depression 23 was issued by JTWC at 0000 GMT 5 October 1979. Although the surface pressure did not drop significantly, the observed surface winds did increase, and as a result, Tropical Depression 23 was upgraded to Tropical Storm Tip at 0000 GMT 6 October 1979.

During the period from 5 to 7 October 1979, Tropical Storm Tip gave a striking example of what the term "erratic movement" really means. Tropical Storm Tip first executed a cyclonic loop southeast of

Truk, then accelerated to the northwest, only to stall and meander to a position south of Truk. It was difficult to keep track of Tropical Storm Tip's surface position during this period. Tip's initial best track positions illustrated in Fig. 3 were based almost entirely on aircraft surface positions, because the satellite fixes were based on the upper level outflow center, and even the 700 mb center, as observed by aircraft reconnaissance, was displaced from the surface center by 60 km. Changes in the surface wind direction reported by Truk assisted the JTWC in monitoring Tropical Storm Tip during this period of erratic behavior.

Post-analysis shows that Tip's slow development and early erratic behavior were related to the weak, yet extensive circulation patterns that were associated with Tropical Storm Roger. While near Truk, Tropical Storm Tip was still competing with Tropical Storm Roger for the strong southerly surface inflow and, until 8 October 1979, was coming out second best. Fairly strong southeasterly mid-level steering

<sup>6</sup> The Aerial Reconnaissance Weather Officer (ARWO) estimates surface winds by observing the sea state.



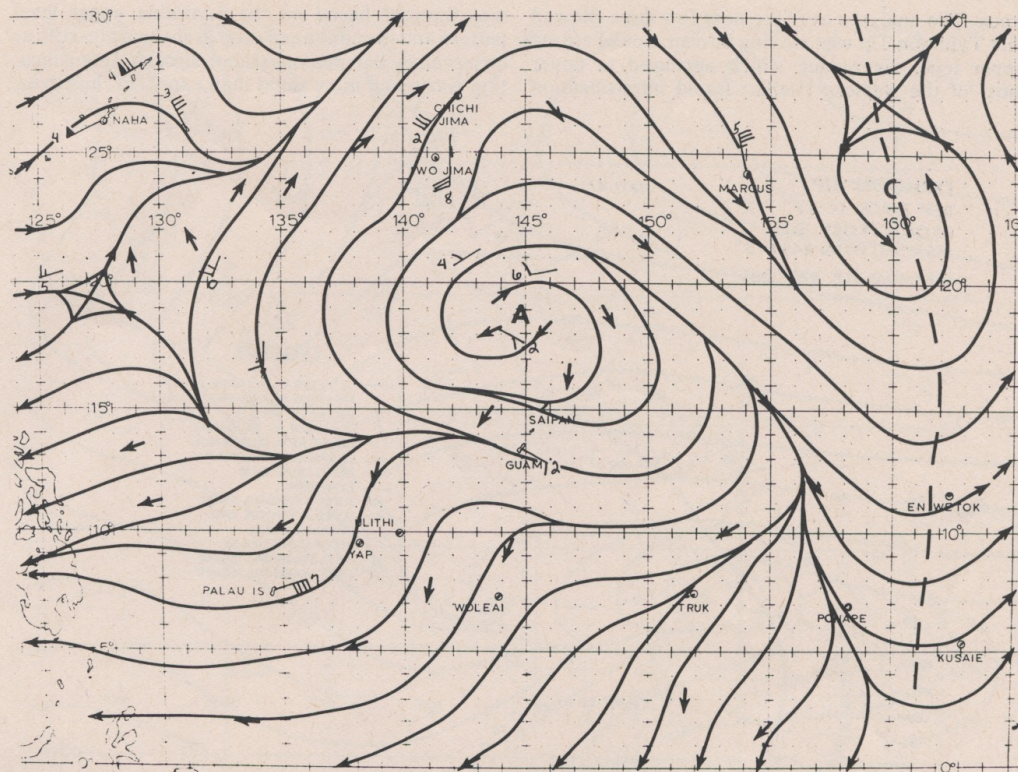


FIG. 2. The 0000 GMT 3 October 1979 200 mb streamline analysis. The analysis is based on a composite of island station rawinsonde reports (winds in knots), aircraft reports (winds in knots) and satellite blow-off wind vectors (direction only). The data were chosen at approximately the 200 mb level.

winds, observed at Guam and obtained from reconnaissance aircraft, were expected to steer Tip toward Guam. At this stage of development, however, Tip was evidently too far south of this wind band and the steering in the immediate vicinity of Tip remained weak.

On 8 October 1979, the expected northwest movement began. Roger, far to the north, was becoming extratropical, and the southerly low-level winds that had been flowing north began to veer toward Tip (Fig. 4). The TUTT cell earlier near Marcus Island had migrated to a position northwest of Guam, affording Tip an excellent outflow channel to the north (Fig. 5). Synoptic and subsequent aircraft data revealed that the southeasterly mid-level winds finally began to influence Tropical Storm Tip, and an aircraft storm fix at 0208 GMT 9 October 1979 confirmed that Tip was heading toward Guam at  $\sim 24$  km  $h^{-1}$ . The minimum sea level pressure had dropped to 995 mb and surface winds were 21 m  $s^{-1}$ .

Tropical Storm Tip continued to intensify and accelerate, eventually to 37 km  $h^{-1}$  on its track toward Guam (see Fig. 3). Until 6 h before reaching Guam, Tip's persistence track indicated that the storm would pass directly over the center of the island. Six hours before expected landfall, however, reconnaissance aircraft and radar positions from Detachment 2, 1 Weather Wing, Andersen Air Force Base showed that Tropical Storm Tip had turned westward. Tip actually passed 45 km south of the southern end of Guam at 1015 GMT 9 October 1979. Maximum winds of 25 m  $s^{-1}$  with gusts to 33 m  $s^{-1}$  were recorded at the Naval Oceanography Command Center on Nimitz Hill, which is located near the center of the island. Andersen Air Force Base, located on the northern end of Guam, recorded 23.1 cm of rain in the 25 h period ending at 1900 GMT 9 October 1979.

Shortly after passing Guam, Tip reached typhoon strength and continued on a basic west-northwest



track. The analyses over the next few days showed that Typhoon Tip was moving into an area of strong upper level divergence which appeared to cover most of the western Pacific. Rapid intensification

was forecast based on the favorable upper level pattern and the continued drop in surface pressure as observed by the reconnaissance aircraft. Intensification was much more rapid than expected, however,

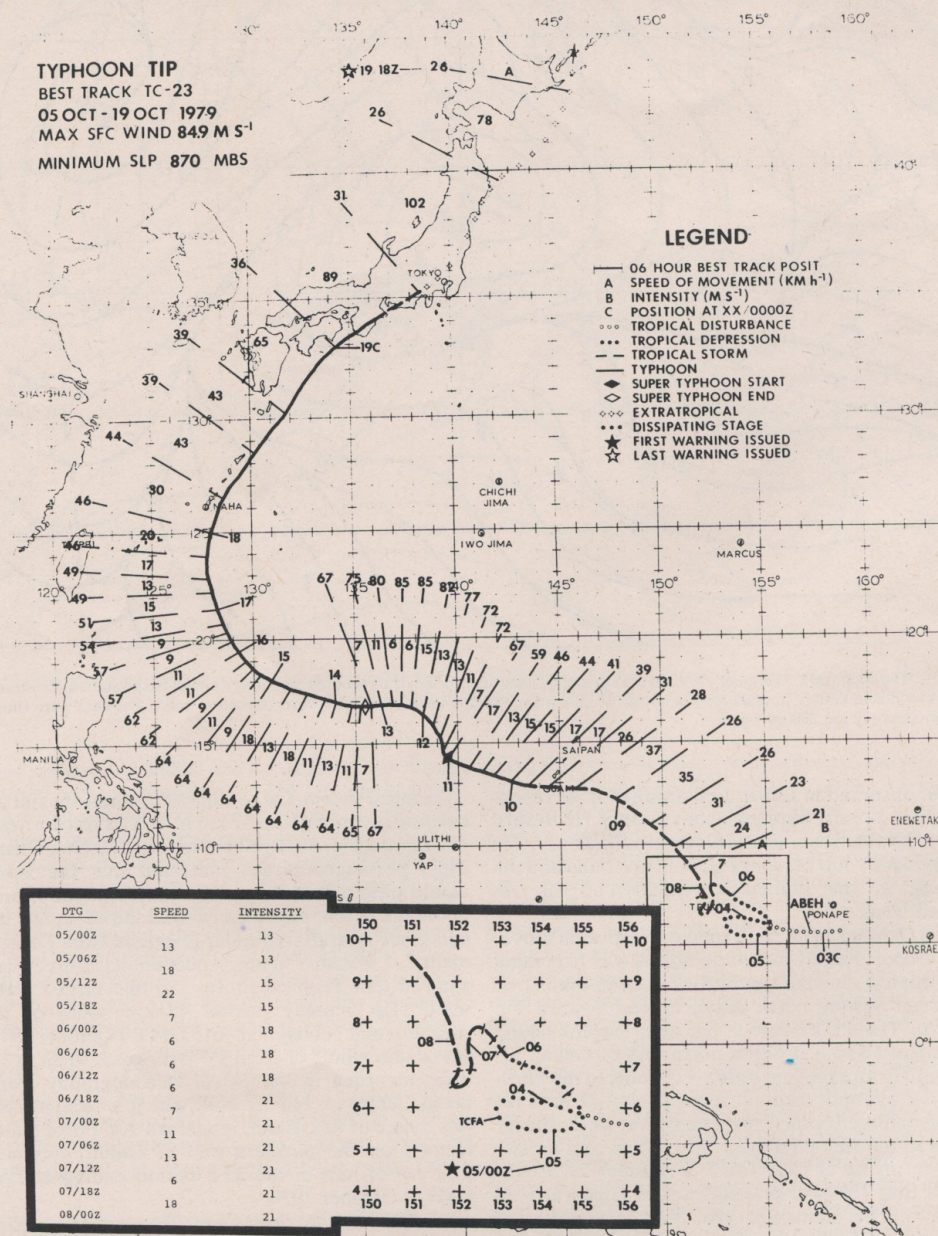


FIG. 3. Best track for Super Typhoon Tip.



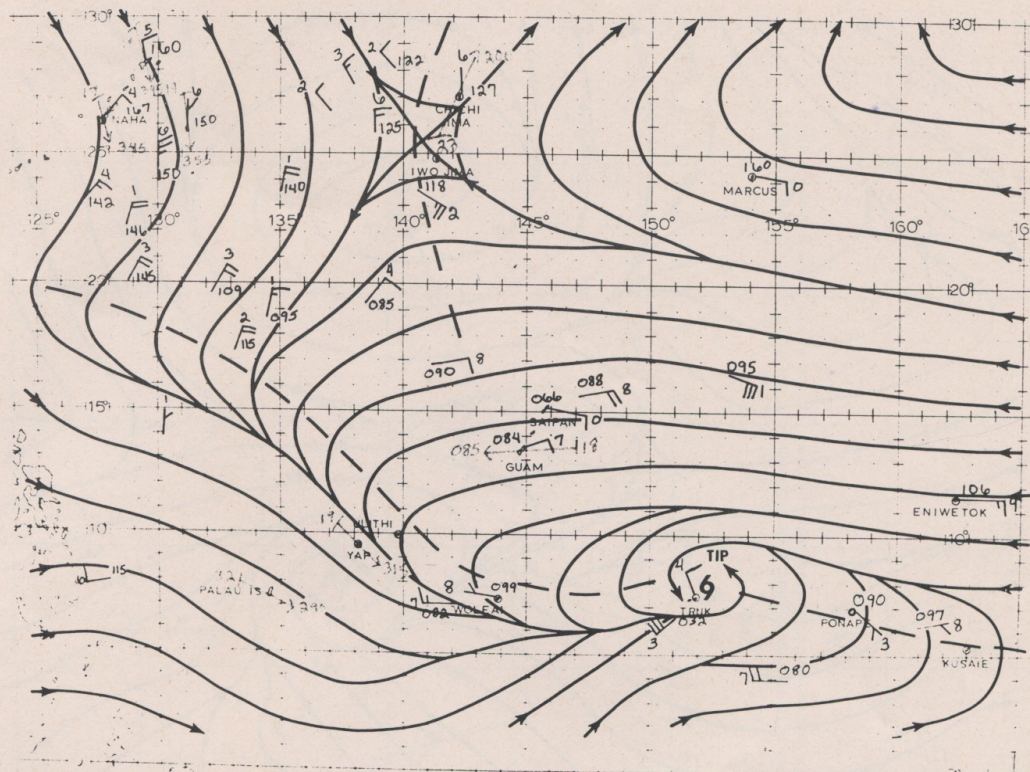


FIG. 4. As in Fig. 1 except data are for 0000 GMT 8 October 1979.

as the pressure dropped 92 mb to 898 mb between 9 and 11 October 1979 (Fig. 6). Tip reached super typhoon strength during that period, with maximum surface winds of  $67 \text{ m s}^{-1}$  reported by reconnaissance aircraft. During one 27 h period, Tip's central pressure dropped 59 mb, which satisfied the criterion for rapid deepening (greater than or equal to 42 mb in 24 h) as established by Holliday and Thompson (1979). The surface analyses revealed that the circulation pattern associated with Typhoon Tip had increased to a diameter of 2220 km which surpassed the previous record of 1330 km set by Typhoon Marge in August 1951.

### 3. Mature stage

Super Typhoon Tip intensified still further, and at 0353 GMT 12 October 1979 a reconnaissance aircraft recorded the lowest sea level pressure ever observed in a tropical cyclone: 870 mb. This pressure was measured by dropsonde and was 6 mb lower than the previous record set by Super Typhoon June in November 1975. The 700 mb height was 1944 m and the 700 mb temperature within the eye

was an exceptionally high  $30^\circ\text{C}$ . Fig. 7 is Defense Meteorological Satellite Program (DMSP) imagery of Super Typhoon Tip shortly before the reconnaissance aircraft recorded a sea-level pressure of 870 mb. The Aerial Reconnaissance Weather Officer (ARWO) on that particular mission remarked "... one unusual feature was the spiral striations on the wall cloud. It looked like a double helix spiraling from the base of the wall cloud to the top, making about two revolutions in climbing." Tip maintained super typhoon strength for the next 54 h while moving to the northwest at between 6 and  $13 \text{ km h}^{-1}$ . Estimated maximum wind intensity of  $85 \text{ m s}^{-1}$  was reached at 0600 GMT 12 October 1979.

The immense circulation pattern associated with Typhoon Tip extended from the surface through 500 mb (and probably higher) and essentially split the subtropical mid-tropospheric ridge south of Japan. This would have allowed an average typhoon to re-curve sharply to the north, but Tip was an atypical

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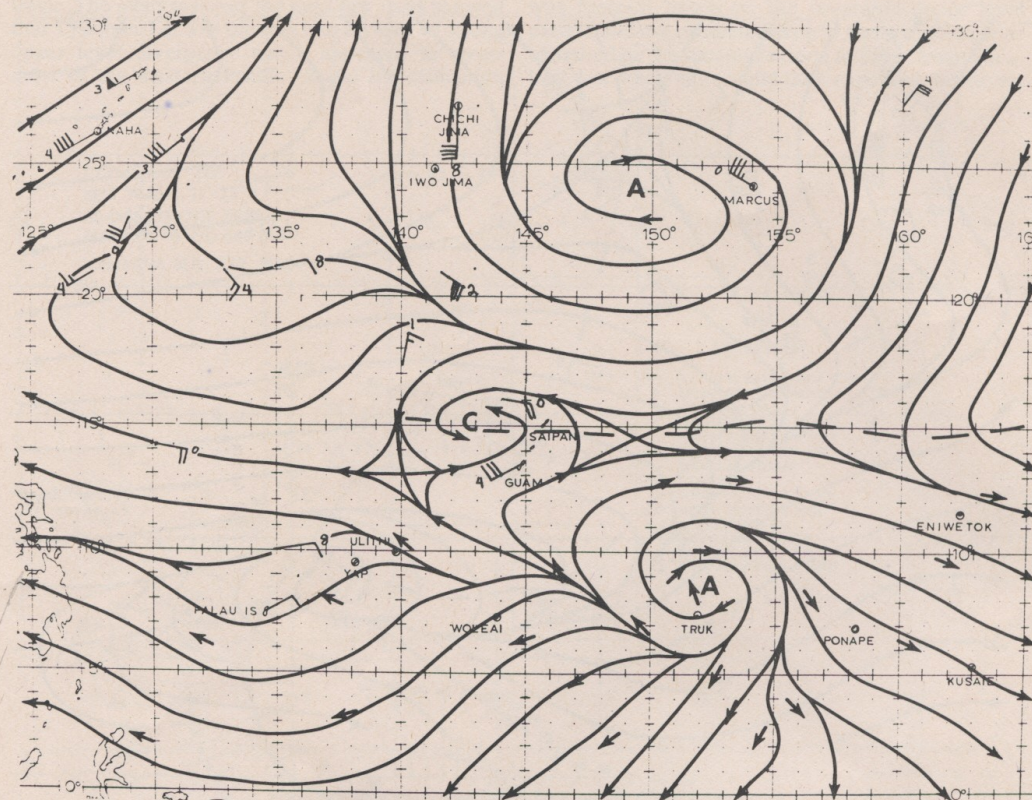


FIG. 5. As in Fig. 2 except data are for 0000 GMT 8 October 1979.

system and the northwestward movement persisted for the next three days.

From 13 to 17 October 1979, the average radius of surface and gradient-level  $15 \text{ m s}^{-1}$  or greater winds (as determined by aircraft and synoptic data) extended over 1100 km from Super Typhoon Tip's center. The radius of over  $26 \text{ m s}^{-1}$  winds was over 280 km (see Fig. 8). The aircraft reconnaissance data in Fig. 9 likewise showed that 700 mb winds of  $54 \text{ m s}^{-1}$  (105 kt) existed more than 220 km from Tip's center during this period.

#### 4. Extratropical transition stage

After 17 October 1979, Tip began to weaken as the large circulation pattern began to reduce in size. This, together with the effects of a mid-level trough moving toward Japan from China, caused Tip to begin tracking northward. By 18 October 1979, Tip was accelerating to the northeast under the influence of the increased mid-level southwesterlies.

During recurvature, Tip passed 65 km east of

Kadena AB on Okinawa, which reported maximum sustained winds of  $20 \text{ m s}^{-1}$  with gusts to  $31 \text{ m s}^{-1}$ .

At approximately 0100 GMT 19 October 1979, after reaching a forward speed of  $\sim 75 \text{ km h}^{-1}$ , Typhoon Tip, with maximum winds of  $36 \text{ m s}^{-1}$ , made landfall on the Japanese island of Honshu,  $\sim 110 \text{ km}$  south of Osaka. Tip continued to accelerate and synoptic and radar data from stations on the island showed that Tip maintained a forward speed in excess of  $78 \text{ km h}^{-1}$  while passing to the north of Tokyo then northeastward over the Pacific Ocean. According to satellite imagery, Tip completed extratropical transition over Honshu.

The extratropical low pressure center (the remnants of Tip) maintained winds of  $25 \text{ m s}^{-1}$  until 21 October 1979 when it moved to a position east of Kamchatka and finally began to fill rapidly.

#### 5. Concluding remarks

The majority of the severe damage due to Super Typhoon Tip occurred in Japan where the agricul-



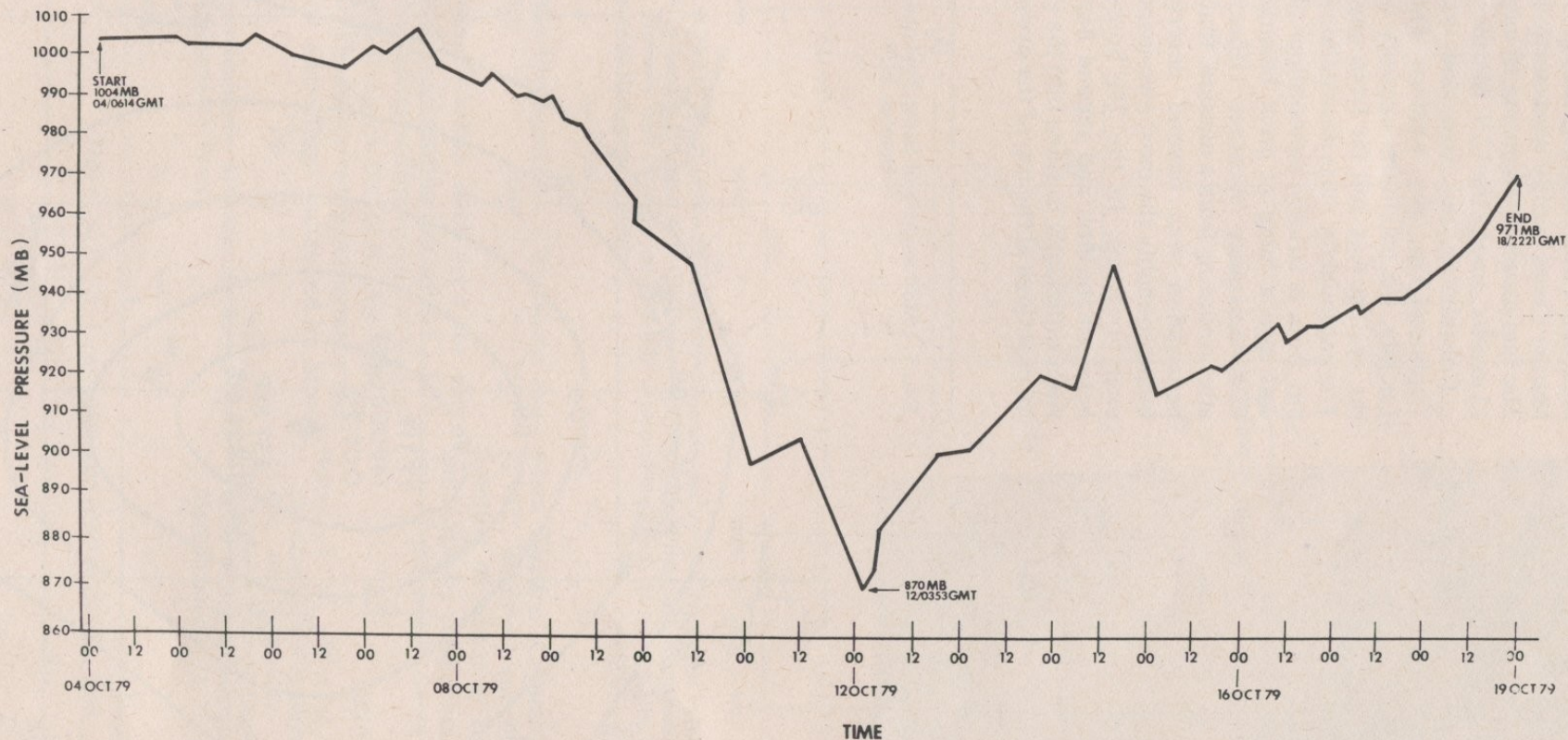
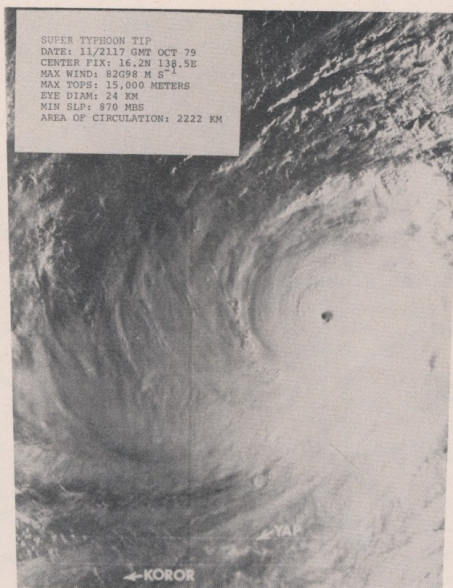


FIG. 6. Time/pressure trace for Super Typhoon Tip. The values were determined either from reconnaissance dropsonde data or from extrapolated 700 mb height data. The complete aircraft, satellite and radar fix data on Tip can be found in the Annual Typhoon Report (Joint Typhoon Warning Center, 1979).

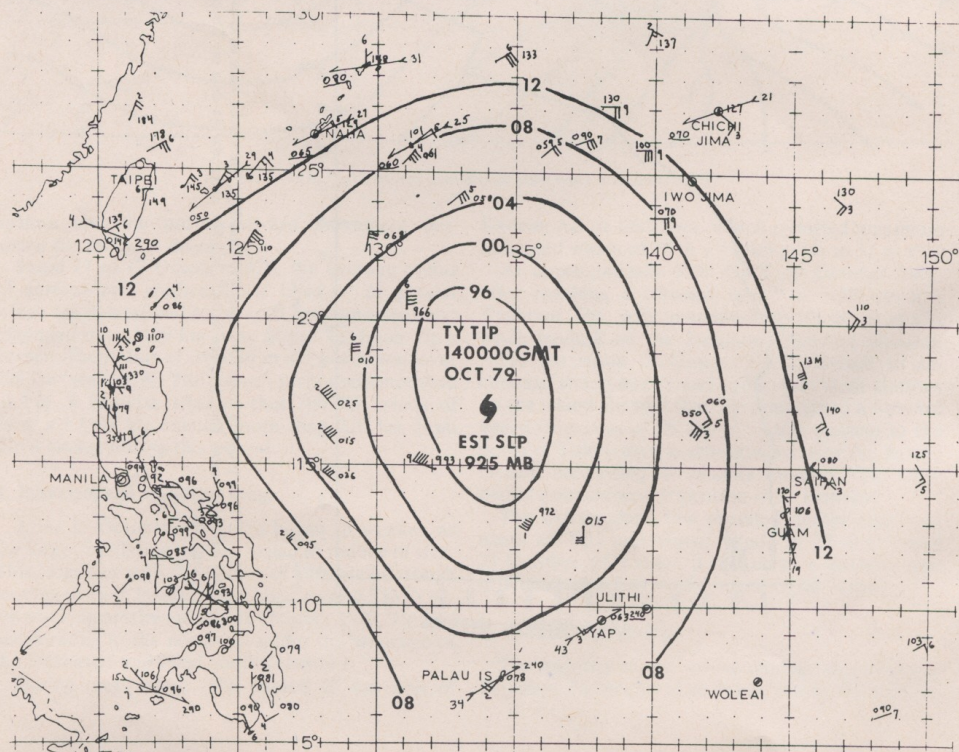




tural and fishing industries sustained losses into the millions of dollars. Flooding from Tip's rains also breached a fuel retaining wall at Camp Fuji, a U.S. Marine Corps facility west-northwest of Yokosuka. The fuel caught fire causing 68 casualties, including 13 deaths, among the U.S. Marines stationed there.

Considering the size and strength of Super Typhoon Tip, the western Pacific fared well. Luckily, the maximum intensity was reached while the system was still far from any inhabited areas. The potential for mass destruction was always there, but from a strictly meteorological standpoint, Tip was also a thing of great beauty. Another Aerial Reconnaissance Weather Officer stated, shortly after returning from a mission, that "... the second penetration was beyond description. This was unquestionably the most awe-inspiring storm I have ever observed. In the 2½ hours that transpired between the first and second fixes, the moon had risen sufficiently to shine into the eye through an 8 mi clear area at the top of the eyewall. To say it was

FIG. 7. DMSP imagery of Super Typhoon Tip at 2117 GMT 11 October 1979.





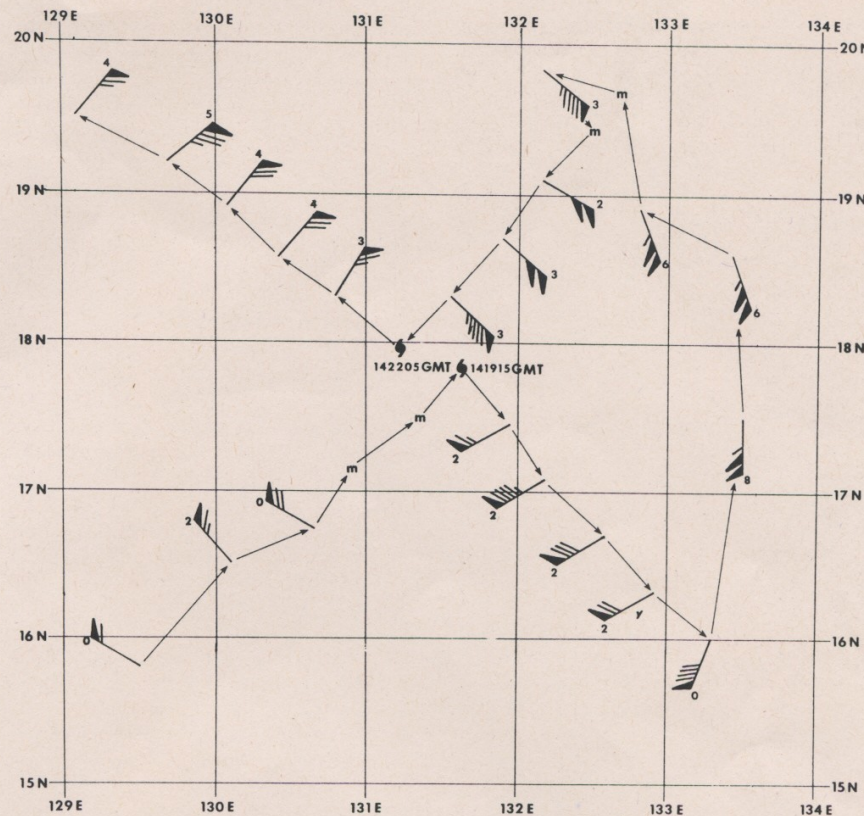


FIG. 9. Plot of data from the 26th aircraft reconnaissance mission into Super Typhoon Tip. Tip's positions were fixed at 1915 and 2205 GMT on 14 October 1979. Wind barbs are measured 700 mb winds in knots. The tens digit of the wind direction is also plotted with the wind barbs. An *m* indicates no 700 mb wind data were available.

spectacular is totally inadequate . . . 'awesome' is a little closer."<sup>8</sup>

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